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Asbestos Exposure Dose Reconstructions

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SPEAKERS:

Fred Boelter
Doug Fowler
John Spencer
Jim Rasmuson
Bill Dyson

Transcript from audiotapes

BROWN REPORTING, INC.
1740 Peachtree Street, N.W.
Atlanta, Georgia 30309
(404) 876-8979

SPEAKER: The AIHA and ACGIH presents Asbestos Exposure Dose Reconstructions, recorded live at the American Industrial Hygiene Conference and Expo 2002.

SPEAKER: This is the Asbestos Exposure Dose Reconstruction Forum 244. We have five people here today. One person, unfortunately, was not able to make it.

I would like to introduce everyone at the beginning. This session, by the way, is sponsored by the Risk Assessment Committee of AIHA, and in the back of the room there is a handout that is available for the risk symposium that is going to be sponsored by the Risk Assessment Committee as part of the PCIH this September in Cincinnati, so please pick up a brochure.

I think there is an AV person outside.

Are there any questions?

(Technical difficulties.)

I hope you enjoyed your computer class this morning.

FRED BOELTER: The speakers today are -- Larry Birkner was unfortunately unable to join us. Larry is a Certified Industrial Hygienist and Certified Safety Professional.

I am a -- I am Fred Boelter, and I am a Certified Industrial Hygienist and a Licensed Professional Engineer. I have been in the occupational arena since 1973 and have been in the consulting field of my own since 1985.

Bill Dyson is a Ph.D. and Certified Industrial Hygienist with Workplace Group. He has an undergraduate in chemical engineering and a masters and doctoral degrees in environmental health engineering. He is also the Past President of the American Academy of Industrial Hygiene and has been an officer with the AIHA.

Doug Fowler is a Ph.D. and Certified Industrial Hygienist with Fowler Associates. He's a lecturer for several courses in industrial hygiene at Berkeley. He is also a former program manager with the Stamford Research Institute. He has been a peer reviewer of a number of articles in the Journal of the American Industrial Hygiene Association.

Jim Rasmuson is a Ph.D. Certified Industrial Hygienist and Diplomat of the American Board of Toxicology. He has a Ph.D. in analytical chemistry and is certified in both the chemical aspects as well as comprehensive practice of industrial hygiene.

He has authored a number of papers, including an award winning study on Pathways of Lead Uptake in Kazakhstan Infants and Children.

John Spencer is a Certified Industrial Hygienist, Certified Safety Professional, Registered Sanitarian. He is President of Environmental Profiles in Baltimore and has been a team leader for NIOSH as well as a hygienist for the Coast Guard.

I want to give a quick overview of dose reconstruction. Dose reconstruction is a science based on an exposure assessment. It's fundamental application is in source pathway receiptor analysis, patent transport as some might know it. Its applications are in risk assessment, accidental releases or disturbances, epidemiologic studies and disease attribution.

Dose reconstruction is an examination of past activity potential for injury or disease attribution. It is also an examination of the risk presented by a recent unanticipated exposure.

Techniques are generally accepted by the scientific community and it is reproducible within an acceptable degree of scientific certainty. The process is one which is intended to correlate the dose with epidemiologic information and standards.

An exposure assessment is the estimation and measuring of exposures and it is a fundamental part of industrial hygiene and it has been around for more than 60 years. It has been defined and laid out in a number of studies over the past 20 years.

The National Academy of Sciences' four-step paradigm, which includes hazard, slope factors, exposure assessment, and risk assessment, was published in 1983 and is known as the Red Book.

U.S. EPA Risk Assessment Guidelines for Superfund was published in 1985 and contains essentially the same process.

The U.S. EPA exposure factors also in 1989 contain information that is useful in a dose reconstruction, as does the Agency for Toxic Substances Disease Registry, the ATSDR, '92, the U.S. EPA Guidelines for Exposure Assessment in '92, as well as the ASTM Rebecca Guidelines of 1985.

In reconstructing a dose, we need an exposure assessment. Exposure assessment is based on estimates of concentration, work activity duration, employment duration, as well as information that is based on memory, hard data, experience, extrapolations, interpolations, interpretations, reconciliation, judgment, logic. A reconstructed

dose is an estimated range.

Ultimately when we do a dose reconstruction, looking at the result, it has to make sense. Clearly if the dose that is calculated is too high or too low, from what we know as industrial hygienists to be a reasonable range, we have to go back and take a look at the assumptions or the estimates that were used in reconstructing that dose.

A simplified dose calculation is concentration times time equals dose. We have an exposure, we have a duration of that exposure, that is equal to the dose.

The concentration is going to be based on the activity being performed, the source of the contaminant, the controls that are in use, as well as the proximity of the individual to the source.

Time is going to be based on the duration of the task as well as the length of employment.

In reporting dose related to asbestos specifically, the dose is reported in the term that is called fiber years per mil, or frequently known as fiber years. It is typically reported as a range of likely doses. It may be a probability distribution, and it may be compared against some reference.

What will follow in this forum are the

techniques used by six professional industrial hygienists who practice in different parts of the country, and the dose reconstructions are performed in essentially the same way: Build a timeline, reconcile the information, judge the information, select empirical data for use, generate missing data, if possible, and then ultimately analogize in the absence of directly applicable data, and from this process, we calculated a range of likely doses.

What I would like to do is to have Doug Fowler do the first presentation as is the order in the announcement.

DOUG FOWLER: Thanks very much, Fred. This is a distinguished audience here today. One of my former colleagues, Dr. Roy Balzer is here, Dr. Jack Peterson, Mr. Allen Rogers, Mike Williams, Barbara Cohrssen, many people who are my peers in age, at least, some of whom were my bosses from time to time, and it is a great honor to be presenting this material to you.

The work I will describe was done on behalf of attorneys for a Plaintiff in the asbestos litigation. The question was really whether a particular kind of exposure was "significant" or "substantial," and those are words which have special

legal meaning, I am told. They may have special industrial hygiene meaning as well.

This was a unique -- this stuff is way too complicated for me, I am an old person here.

What was the purpose of the evaluation? Basically the Plaintiff had mesothelioma, and the presumption is that a person who has mesothelioma and who had asbestos exposure developed the mesothelioma as a consequence of that asbestos exposure.

This fellow had had a relatively brief and relatively light history of exposure to asbestos. And I will go into that in a bit. But the specific question was whether the product manufactured by one of the Defendants, who was a gasket manufacturer, could have given rise to exposures to asbestos that were significant or substantial.

Now as I am sure most of you are aware, ordinary exposures in handling of gaskets in the normal course of work with gaskets are relatively trivial; however, in this case, the gaskets were stacked and he band sawed those gaskets over a period of a day or so each time he did this activity. And so the Plaintiff's lawyers contended that this operation contributed in some meaningful way to this man's disease.

So the question that was asked of me was, is that true? Because the Defendants said no, this is a gasket cutting operation, we all know that cutting gaskets doesn't give rise to significant exposures, and thus this activity did not contribute to the Plaintiff's disease.

And the Plaintiff's lawyers, people for whom I have done work over the years, came to me and said: Are we right or are we wrong? And by the way, they retained me as a consultant first, and then when I gave them the answer, they offered me as an expert witness.

He worked in the shop of a subcontractor to the aerospace industry, and he made insulation pads that were formed of stacks of neoprene asbestos gasketing. His employer told him that the way we do this is to cut them with a band saw, and so he did that work exactly as his employer directed him to do.

Approximately over the period of 1958 to 1962, perhaps slightly longer, he didn't remember how many times he had done this, but he did remember that each time it was a full day's activity, eight to nine hours.

And did he have other asbestos exposures? Yes, he did. In the course of making this piece of

equipment for which the stacked gaskets were applied, he also cut calcium silicate block insulation, which was used in a conventional fashion for thermal insulation on a tank of heated liquid. Because the manufacturers of the block insulation had settled their case with the Plaintiff, I wasn't asked to compare those exposures; however, in the course of some work quite a long time ago with Dr. Balzer, we had done some studies of potential exposures on a short-term basis in band sawing calcium silicate block insulation, and I will present that information to you today so you can get some sense of the differences.

So, my assignment was perform a simulation of the gasket cutting activities and operations as described by the Plaintiff.

Number 2, determine whether the asbestos exposures arising from the gasket cutting operations were significant or substantial. What's not stated there is call the lawyer and tell them what my conclusions were.

Assuming then that the lawyer believed that this might be helpful to his case, then prepare a report and prepare for testimony at time of trial.

So what did I do? I went and bought some

gasket. Still bought it in 1996. I built a little-bitty chamber, 650 cubic feet, and about 3.2, 3.7 air changes per hour through a HEPA filtered unit. Bought a band saw, put it into the chamber.

And there is the band saw. There is the chamber. You can see it is one of these little-bitty adjustable negative air pressure units in the back there. And I operated it at the very lowest rate that I could so I wouldn't overwhelm this small chamber with air movement.

Here is the band saw. There is some debris. There is some of the pieces that I cut. Air sample filters set up ready to go.

I cut the sheet into manageable sheets. This was rolled -- it was very tightly rolled, and I had to cut it into chunks about so big in order that I could handle it comfortably at the band saw. Put it down, put weights on it, let it flatten out.

I performed the simulation, and the samples were sent to a qualified lab. The R. J. Lee Group was the laboratory that I used. I determined the potential exposures. Called the lawyer. Wrote a letter. And the case was settled.

And that's a guy you might recognize there doing the cutting. And essentially, this is in the

actual course of cutting of this, and you cannot see any airborne dust arising, which may have some significance in terms of recollections of folks.

By the way, the Plaintiff in his deposition couldn't recollect seeing any airborne dust, except when he was cutting the calcium silicate material.

All right. So, what are my results? Well, I took a sample during the saber saw cutting of this material in order to determine whether or not there was any significant exposure. And you will see that I had the samples analyzed three different ways, by phase contrast microscopy, by total structures per cc by TEM, and by structures greater than 5 micrometers by TEM.

Saber saw cutting, less than .1 by PCM. By TEM, and greater than 5 TEM, somewhat higher. Here I have the personal samples. Four personal samples during band sawing. PCM concentrations, 3.1 and 2.2 and 4.9 and 3.1, on average about 3.3 fibers per cc.

Area samples, somewhat lower but not too much. Note that here these two samples, which I took for 25 minutes each, total volume in the samples of about 250 liters, were both too overloaded for direct

preparation TEM analysis, and so I did not have them analyzed.

Again, area samples in the ballpark of about 2 fibers per cc. So about two-thirds as high as the personal samples.

Now, if we wanted to compare, which I didn't do for this case, but if you wanted to compare this work to concentrations that might arise from band sawing, some work that Dr. Balzer and Dr. Cooper and I did in the summer of 1970 was relevant. The sample and analysis was different, this was a predecessor method to the P & CAM 239, but essentially equivalent to that method, 37 and 47 millimeter filters were used.

We tested 3 different brands of calcium silicate, and we took 9 samples for each brand. And we had a couple of different area samples as well as personal samples in the breathing zone of the guy who was doing the work, and as opposed to 2 to 3 fibers per cc from the band sawing of gasketing material, here we have average concentrations in the range of 50 to 200 plus. So, although we couldn't determine fiber burden, I couldn't calculate fiber years of exposure because the Plaintiff couldn't remember how often or really for how long he did the work.

I concluded that his exposures were both significant and substantial during each episode of band sawing the gasketing material, and his exposures were well above the current and recent past OSHA PELs during each episode.

Although the conditions were not identical, we had a bigger chamber, we used a different band saw, we used a different sampling and analytical method, it is possible to conclude that exposures from calcium silicate sawing were in the range of 10 to 100 times greater than from the gasket sawing. And it was also possible to conclude, remember based on one sample during saber sawing, that band sawing produced higher concentrations than did saber sawing.

Our recommendations -- this was published a couple of years ago, by the way, in The Applied Industrial Hygiene mag, we concluded that such gasket sawing should not be done without controls. And remember, I bought this stuff from the manufacturer of the gasketing material. I called him up and said I want a roll of it and he said okay, and I sent him money and he sent me the gasket.

We concluded that if the desired goal for control is that asbestos exposure should be no higher

than ambient concentrations of asbestos; i.e., no higher than about 1/1,000ths of a fiber per milliliter, then supplied air respiratory protection is needed together with other, as you would expect, other environmental controls.

Now, it is noted that as of 1996, the manufacturer specifically recommended against such uses as sawing these gasketing materials, and this was in the form of an enclosure with the material as well as the sticker on the box in which it came, so that as is usually the case, things now are not the same as they were then, conditions have changed and our understanding of the risks associated with asbestos have also changed.

If it is my conclusion as to how I would like to control this material, I would say don't do it. I mean, clearly this is a case where substitution of a nonasbestos product is entirely appropriate.

Thank you very much.

(Applause.)

FRED BOELTER: Thank you, Dr. Fowler. I am now going to ask John Spencer to give his presentation.

JOHN SPENCER: Thank you, Fred, and good

morning to you all.

I think that is great.

As an industrial hygienist, I have been involved in a number of different federal agencies and worked for private organizations and I have my own consulting group now as I have for the past nine to ten years. As part of that I have been asked to do a number of exposure assessments, and asbestos has certainly been one of the types of exposures that even today doesn't seem to go away, so -- however, the types of products certainly have changed, and as industrial hygienists we are asked the question to differentiate and evaluate exposures to asbestos and many other products, but just because a product has asbestos in it, does it carry the same weight, that is, does a friable product present the same type of exposure as an encapsulated product. So often I am asked to make the -- to differentiate and determine the difference between those two types of products.

Now the example I am going to present to you this morning deals with exposures, primarily shipboard exposures, which having worked with the Coast Guard and worked on other Navy vessels and clients today who are involved in scrapping of ships, including military vessels. We continue to do these

types of exposure assessments, and I want to differentiate the contribution of exposure from a friable product pipe insulation, primarily, versus an encapsulated product. And in this example I am going to use a gasket material.

We have gone, certainly in this country and around the world, from being concerned about exposures. Magnitudes of levels have changed. I know in growing up, in my time we were worried about rivers catching on fire and now we are concerned about parts per quadrillion of a particular chemical in that same river. So our priorities have changed but it is often difficult to differentiate the low-level exposure from some of the higher levels of exposure.

In this example, what I am going to utilize -- what I am actually going to do is calculate a dose, a fiber year dose based on various parameters that I will identify in a moment, but we are going to assume this individual had six years of Navy experience, and we will define the tasks that that individual was doing. He worked around friable insulating materials, primarily removing these materials, as part of his job activities, and also in conjunction with that, removed some gasket products.

Again, the purpose for retrospective exposure assessment is because as industrial hygienists we can't always go back in time and monitor each and every workplace environment. We don't have data for each and every specific situation that an individual is in, so there is a scientific process for going backwards in time and assigning an exposure as a best estimate, or in most cases, a worst case scenario.

In doing an exposure assessment, I kind of -- in review of the literature, and in particular the one book that sold through the American Industrial Hygiene Association, The Strategies for Occupational Exposure Assessment, and also what used to be the NIOSH White Book, which is also now sold through the AIHA, The Occupational Environment's Evaluation and Control, defines the scientific process for doing an exposure assessment, and certainly there is many other papers on this process as well.

I have basically broken these down into four different areas, which includes characterizing the product itself, is it a friable product or is it an encapsulated product. Looking at the workplace environment, if I am going to do a retrospective

exposure assessment, is the environment in the published literature or the reports that I am looking at similar to the environments that the individual that I am focused on worked in, is it similar or the same, was the ventilation the same, was the air movement, was the size of the room the same.

And then also as importantly, look at the task descriptions themselves. Is the data that we have on the actual tasks, including the frequency and the duration of those tasks, is that similar or the same as what is in the reported documentation, the literature or other studies that have been done.

And finally, were there controls that were used, local exhaust ventilation or other fans in the area, or even respiratory protection.

Other considerations: Are the sampling and analytical methods the same or similar from each of the studies that I am using. That is why we, as industrial hygienists, use a standard NIOSH and OSHA sampling and analytical methods, so we can compare our data over time and among one another. Unfortunately this is not always done out there, and you need to use caution when evaluating this data.

Just as a side bar, one of the areas that I have been looking at most recently has to do with

brakes, automotive brakes, and it is very interesting to me. If you look at that data, a lot of it is -- they might have PCM data, but they never did a bulk sample analysis to determine whether there was any asbestos in the product or not. They didn't do TEM data to determine whether the PCM fibers they were seeing in the air were asbestos or not.

So it is important that we use standardized sampling and analytical protocols, and when you refer to the literature that you use, only that literature that has those standardized and accepted protocols.

And what I am talking about there in particular, today we used the OSHA 7400 Method and we used the TEM method 7402 as a backup, not necessarily to count fibers, but to develop a ratio which is then used and applied to the results of the PCM data. In other words, if you find 50 percent -- if you have one fiber per cc by PCM analysis, and you want to do a TEM because you think some of those may be cellulose fibers or cotton fibers, you use TEM, and if you come up with 50 percent of your fibers being nonasbestos, you apply that 50 percent ratio to your PCM findings.

That is how OSHA basically spells out and

how NIOSH spells out the use of the 7400 and the 7402. It is not always used that way, so again you have got to use caution when you are using historical exposure data.

The other thing that I found, there are people today who are out there doing what they may call an exposure assessment, and they are using environmental air sampling and monitoring and analysis methods and don't clearly understand the difference between an environmental assessment, in which you are looking for the presence of a particular material like asbestos, versus an occupational exposure assessment, where you are looking to compare your results to the occupational health standards.

So again, one must use caution when selecting the appropriate data.

What I did for the data I am about to show you is I collected data from shipboard monitoring exposures done historically. And it was also based on a lot of my own experience in removing the, I would say, miles and tons of friable pipe insulation from Coast Guard and Navy vessels.

I also have data of gasket fabrication studies that have been conducted over the years by a

variety of people. Probably the earliest and most well-documented one was one done by the Navy. Larry Liukonen and others conducted a study, the Bremerton Naval Shipyard in the late 1970s. Used that data.

I have conducted my own assessments in chambers under controlled conditions, and I will talk a little more about that, and have generated data that was similar.

Obviously the shipboard environment, for those of you who haven't been aboard, machinery spaces are the main focus of the insulating materials. We have done calculations taking ship specifications and have actually computed the amount of friable materials, pipe insulation and cement that was aboard the ships.

This is just from machinery spaces, and we are looking at amosite asbestos felted over almost 17,000 linear feet. The insulation of cement was primarily used around pipe joints and valve assemblies, nearly 250 pounds of that material. This is per ship. Just in the engine room and the boiler rooms, doesn't even count the rest of the ship.

So we had a lot of mixture of both amosite and chrysotile, but you can kind of get the sense for the amount of material on board these ships.

From the exposure data, and it seems that Dr. Balzer's name and Dr. Fowler's name keep coming up in some of this historical data, and I really don't mean anything beyond that, it was just good historical data.

Did a number of studies and showed levels of exposure from 16 to almost 114 fibers per cc. There is other data out there. Another commonly quoted shipboard exposure set of data is a British study from P. G. Harries. Again, you have to look at -- when you are going back and doing retrospective exposure assessments, you have to use caution.

In using some of that data, their numbers were even higher than this. I believe that some of that is attributed to they used a different type of asbestos product that contained much higher amounts of amosite in there. Can't necessarily explain the reasons why other than amosite. My own experience seems to be more prolific in its ability to become airborne. It is a dryer material and less bound into the product itself. So, you have to use caution in the data you are selecting when you are doing a retrospective exposure assessment.

Some of the data, and I will show you a summary of data that we use, but we actually -- I

have been involved in a number of gasket studies. And asbestos-containing gasket materials, as Dr. Fowler pointed out, is still available on the market today. Many of the encapsulated products, that is the case, packing materials, some roofing material.

I have been to Home Depot and bought mastic material to repair a roof on my building has 5 percent asbestos in it. So those products are still on the market.

There weren't a lot of gasket studies as there was for the friable pipe insulation for obvious reasons, thus the need to do some further studies.

When people started focusing on gasket materials as a potential source of asbestos exposure, these types of studies didn't exist because, for the obvious reason, that a friable product is much more likely to release fibers into the environment than an encapsulated product like a gasket material.

We actually set up a chamber where we had no ventilation and we fabricated gaskets, cut them out using a standard trade practices. We removed gaskets, again, using standard trade practices. Scraping and hand wire brushing and power wire brushing.

(This concludes side one. Please turn the type over for a continuation of the presentation.)

JOHN SPENCER: It was important for us when looking at gasket materials to make sure we had the environment clean. We actually wore Tyvek coveralls in this environment because we found that standard clothing, whether cotton or wool fibers, when you are looking at such low levels, would show up under PCM, so you are constantly getting interferences from other types of fibers.

So, that was -- our only source of control was to control fibers from entering the chamber and from fibers emanating from the clothing that we wore.

Just to give you -- the other thing that we evaluated as part of this task and compared that to the literature as well was the task times. And again, it is important to understand how long it took and how frequently someone would do these particular tasks in order to ultimately calculate a dose, a fiber dose.

Gasket removal with a scraper, generally 5 to 10 minutes. Carl Mangold, another industrial hygienist with an extraordinary historical background, we looked at his numbers that he had also

reported and studies that he has done, similar studies under similar conditions, and looked at -- again, looked at the work as I knew it. I evaluated these types of exposures as an industrial hygienist with the Coast Guard, and so we had a good handle on what the task duration was.

And then removing/installing gaskets, looking at the whole process itself. Again, we went to the literature, we pulled out what data was available, we relied on our own studies and then my own experience as well to get a realistic handle on what these task duration frequencies were.

And then again, this is a summary of some of the reported literature on removal, gasket removal with scraping and hand wire brushing, work done by a number of people, including Fred Boelter, who is sitting here today.

There is generally a good consistency in the data. Some of the higher numbers, the Navy Bremerton study, which is the yellow bar, and the Cheng McDermott papers, it is interesting, the numbers are a little higher there, the eight-hour time-weighted averages, but they are different from the other studies that were done, which were in that they were actually done in the field, so there were

no controls for other sources of fibers.

The other studies that were done by Boelter and Carmel and EPI, that is my firm, Environmental Profiles, and Mangold, were done in a controlled setting in that we controlled for other sources of fibers.

So as a result, you see the actual contribution of fibers from the gasket-handling activities.

Now, what I did is I took the data from my review of what the individual described they did. They removed pipe insulation. How often did they do it? What was the frequency and duration? We looked at what they did with regards to gasket, handling gaskets, working with gaskets. And they defined the vessels that he was on, the number of days that he was on that vessel. And there is generally a vessel service history that you can pull this information directly from. You describe the job tasks. This is on duty. Removing pipe insulation. Claims to have done this four hours a day, one time per day. So his total time was four hours per day.

As to gaskets, again, he said he did it four hours a day, one time -- and we just consider that one time a day. Off duty, 16 hours aboard that

vessel.

Here again the same vessel, removing pipe insulation, 8 hours per day, 7 days a week. This was a military type setting. We wanted to present a worst case scenario, so quite often in the military they are working 7 days a week. They really don't have much time off when they are on board these vessels.

Again, this is true for the gasket, removing and installing gaskets, 8 hours a day. We put 5 days a week. Again, that was based on the description; yeah, I did this a little less in terms of handling gaskets. The pipe insulation was something I got into a lot more.

So, the potential exposure for the pipe insulation work, we just took an average number of 16 fibers per cc. Now, that may be a low number, and perhaps it could be a little lower. I think it is a good average number. I think certainly there is an argument for that number to be higher based on the literature.

And he only did this 4 hours a day, so his eight-hour time-weighted average was half of 16, so that is 4 fibers per cc.

He did this, his task occurrence was 45

days per year. You normalize that to a number of years. This is -- so we used -- I don't know what we used here, 365 or 240. Or I am sorry, we divided 45 by, I don't remember now, 240 or 365, and you get the number of equivalent years. And he did this for 6 years. And again, we carried this through all the way for each activity that the individual did.

By the way, this is a very simplified version of this task analysis. There is a lot more detail that goes into this, but time does not permit that description.

So, we have removing pipe insulation, an equivalent number of days, 6 years times 45 days per year. Well, there is 135 equivalent days. His cumulative exposure, it looks like 5.9. If I am reading that correctly from here. That is 5.9 fiber years. Unfortunately I have PPM years up there. We do the same sort of association for benzene. Anything that has a cumulative type of exposure you use the same sort of approach for.

And then over in this column it is just carried out. It is an additive sort of effect. So here we have the pipe insulation for his 6-year exposure at 5.9 fiber years -- I am sorry, that was on board this ship for 2200 days. We added up each

ship and the amount of time that he was on each vessel removing pipe insulation.

We assigned a background level of asbestos while just being on board the ship. Again, there is data. The Navy has conducted studies. I have been aboard ships underway and measuring asbestos as background levels, and we inserted that data, so provided the exposure based on that data as well.

And then we have removing and installing gaskets under this 2200-day period. There was an equivalent of 180 days of removing and installing gaskets. And his cumulative dose as a result of that was .005 fibers per cc.

You add all these up and ultimately what you come out with for insulation, you add up just the insulation exposure, 7.4 fiber years.

The gasket exposure data was 0.005 fiber years. So, ultimately if you are adding up his total cumulative dose, you would add all the gasket data together, you add all of his years in the different vessels that he served aboard with his pipe insulation exposure, and that is how you come out with a cumulative dose.

And that is how you compare one against -- one product type against the other, whereas in years

past when I was working on board these ships, it was nearly impossible to differentiate the exposures from gasket and the total contribution of exposure on board the ship because we had not only asbestos all over the ship, but we had fiberglass and cellulose and other sources of fibers on the ship. It was hard to make that distinction. This is a process that allows us to make that distinction.

These types of -- this type of approach is good in evaluating what I call a worst case scenario. And I think when you approach this, you take the data in that respect and do a worst case analysis, what we tend to do as industrial hygienists, since we can't monitor everyone under every situation at every point in time.

It is a long and it must be a -- it is a meticulous process to make sure that you have selected the appropriate data, that you have applied the appropriate work task frequency and duration, and that you have looked at the product to make sure that it is similar or the same as the historical types of products.

And so through this process one can get an understanding of the relative contribution of various products. And again, you can use this with other

types of exposures. Benzene is another good one if you want to evaluate different types -- different exposures or contributions from different sources.

One of the things that I have found in doing these types of assessment, as industrial hygienists, we use professional judgment, and I think through experience and education that you can apply your common sense to this type of approach, but it is a scientific process that I believe can be utilized to clearly differentiate one type of product from another.

So with that, I thank you for your time.

FRED BOELTER: Thank you, John. The next speaker is Dr. Rasmuson.

JIM RASMUSON: Good morning. Larry Birkner sends his regrets that he couldn't be here. I am honored and pleased to be here in his place.

The objectives that I would like to talk about this morning are to explore methodologies for doing what we are talking about this morning, but particularly with respect to individuals who have had work over a varying history, in other words, construction workers, maintenance workers, people who have -- it is hard to pin them down, they are moving from site to site, they are doing different tasks,

some sites are being exposed to asbestos and other sites they may not be.

I want to demonstrate how the uses of ranges and a particular technique for dealing with those ranges, the Monte Carlo simulation method, can be used in the absence of specific exposure and specific exposure factor data, and I want to discuss how that can also be applied to the -- taking a look at uncertainty analysis relative to the estimated dose reconstruction.

Particularly I want to discuss the differences between variability accuracy, and I want to talk a little bit about the limitations of the method as well as the strengths of the method.

I think that this type of work, it is very important to, just in the beginning, say that we need to not try to find data to support our preconceived notions, but rather let the data drive the conclusions. And this is almost true without saying it and yet it is something that as consultants I think that we need to remind ourselves of once in awhile.

This is one potential solution to the problem. This is a time machine that we have designed, and the rest of the talk will be discussed

and geared towards that. But, actually, no.

I want to talk about the elements of the retrospective exposure assessment very briefly. Others have touched on that. And then we will try to get through that quickly and get into some meat.

Basically what you want to do is determine the work and exposure history, assign an exposure range to each exposure event, estimate exposure factor ranges. Sometimes the exposure events are known for the primary worker, but people in the same area have also been exposed, or they are using different types of products with different asbestos contents, and then we have to apply factors to those primary exposures to help estimate the exposure ranges for the workers being actually exposed.

You want to calculate each exposure event dose range. Now an exposure event dose range is a specific job working with a specific product. In my experience, the more slices you can make of the work history, the better job you can do because you are paying more attention to details. And I will be talking about that later.

The danger in doing that is sometimes if you are working off of a work history, which has been gathered by interviews or from deposition testimony

or something of that nature, there is gaps in periods of time that can be missing and one has to be careful to try to cover those periods as well and include that in the uncertainty analysis.

Then finally, the estimated doses for all the various exposure events are added together to come up with a lifetime exposure range.

The work and exposure history is determined by interview, deposition testimony, workplace and other records. There is other ways of doing it as well, using personnel records, Social Security records, union records, military records, whatever you have that allows you to piece that together.

In interviewing workers, these are some of the principles that I have come to adopt. I don't always get to interview workers, particularly if I am working for attorneys doing that kind of consulting work for Defendants. On the other hand, when I have worked for Plaintiff attorneys, and in other situations, I have been able to better interact with the workers.

These are some of the lessons I have learned from that type of work: Basically to avoid leading questions, have your forms, your questions,

predetermined. A one on one interview is better so you don't have kind of the group biasing and developing kind of a group thing, pushing things in certain different directions. I try to standardize exposure descriptors. Try to use common, if I am talking about estimating a dose, for example, to an organic solvent or dioxin-containing material, that sort of thing. We try to standardize relative to splashes how many drops, how many quarts, what percent of the surface area of the arm, in other words, the top of the arm, the whole arm, did you get wet up to your elbows, was it just your fingers, how long did it stay wet, did you go wash your hands. Things of that nature. We try to put words in terms -- try to use words that the workers can relate to.

We visit the site whenever possible. That is very important. Estimations are best made in ranges because we can't be real precise in this. And if we can get estimations from several sources, that is always the best.

The work and exposure history characterizes each exposure event. We try to define the type of ACMs in the process. We are talking -- the other slide was more general, this is for

asbestos.

The process, hands-on, bystander; et cetera. What duration or overall percent of the work week are we talking about. That can be in terms of minutes, number of times, lots of different units.

How often did that happen. Over how many years did that happen. It is the old intensity, duration, frequency and length of time idea.

Typically all of the information is typically known within broad ranges, and maybe broad ranges at best.

I found it useful when I organize data to put it into a spreadsheet, taking into account the relevant dates, the employer, location, occupation, job description, work environment, what type of product is it, who manufactured it, the personal protective equipment, the duration/frequency/length idea. And I also document by each exposure event in the spreadsheet the related exposure values from the literature, factors, basis for estimations, and then I do the exposure calculations all on the same spreadsheet. It is just very useful to kind of keep organized in that sense. There is different ways of doing it. This is just the way I happen to do that.

Another useful thing that sometimes I do

is I come up with exposure range categories, kind of order of magnitude values dividing the exposure ranges into seven categories, for example. It kind of goes like this, less than .01, .01 to .1, .1 to 1, et cetera. Kind of an order of magnitude thing. And there I use judgment on each exposure event taking into account bystander factors, differences, all the various exposure factors and what the literature might say, and I use judgment. But by using judgment on many individual events, the overall -- I found in my experience that the overall assessment has some measure of objectivity to it.

Basically what we are talking about when we assign the exposure range is we are talking about historical databases. There is a need to standardize these. I think that the more we can talk as a society and to each other about what exposure ranges we are using, and then we can standardize this, it is going to be -- we are going to create more reproducible exposure assessments from one industrial hygienist to another.

We can also do -- we have to be very careful because short-term measurements oftentimes have been made, and that is different than TWA values, and sometimes the literature is confusing and

we have to be very careful about that.

We can make inference from measurements involving similar materials. I have tried to do modeling. The biggest limitation I found when I tried to model the exposures is an unknown source term, that is trying to figure out what is the mass per unit time that enters the air. And I have been able to do some useful work relative to particular exposures using various models, but modeling is problematic in many cases. But principles of modeling can be used to modify data and to better understand.

For example, if you move an indoor exposure to the outdoors and you use a box model, you use the same source term in terms of mass per unit time being put into the air, you can make generalized conclusions. But there again, you have to make -- you have to have caution so that you don't overinterpret what you are doing.

Basically there are elephant-sized exposures, there are medium-sized exposures, and there are snail-sized exposures.

You know, without exposure data, there is quite a bit you can do based on judgment. If you are talking about friable products, then you are talking

about exposures that are generally greater than the 1 to 20 fiber per cc range, either in that range or greater.

Or as Dr. Fowler just discussed, if you take a friable -- nonfriable material and you apply a power tool to it, then of course you can also get into that range.

If you are talking about materials, such as cloths, papers, things of that nature that can give off a little bit of dust but they are not really friable, in my experience they are typically in that 0.1 to 1 fiber per cc range on a time-weighted average; of course it can be less if you are not handling the material much.

If you are dealing with nonfriable materials and you are not rendering it friable, with power tools typically you are in the less than .01 to .1 fiber per cc range. And some simple categorization schemes like this can help fill gaps. And in fact I believe the National Academy of Sciences in their exposure assessment guidelines talks about making extrapolations like this to fill in data gaps.

The exposure evaluation process then essentially is the industrial hygiene process, the